division of the Karu, flora, on the other hand, is classed as Rhætic, while the Ecca, or lower Karu, flora is identified with some part of the Permo-Carboniferous. The latter conclusion, it may be mentioned, is rendered practically certain by the recent discovery in Kashmir of Glossopteris below marine Permian strata, as recorded in the report of the Geological Survey of India for 1902–3. The occurrence in the Ecca beds of Vereeniging of Sigillaria and other European Carboniferous types points to a closer connection between the South African Glossopteris flora and the Carboniferous flora of the northern hemisphere than exists between the latter and the Glossopteris flora of the Lower Gondwanas of India. The Ecca beds of Vereeniging appear to be the equivalents of the Karharbari beds of the Gondwanas. Finally, although deprecating a precise identification, Mr. Seward is of opinion that the Witteberg flora is probably Carboniferous or Devonian—more likely the latter than the former.

That so much good work—both strictly scientific and economic—should have been accomplished during and so soon after a great war is a hopeful sign for the future of South African biology. R. L.

EXPERIMENTS ON WHEAT.

WITHIN the last few years it has gradually been recognised that, although our wheat-fields produce a large bulk of grain, it is, if used alone, unsuitable for the manufacture of the light white bread now generally demanded. In consequence, increasing quantities of the harder and more suitable wheats grown in Canada, the United States and other countries are imported yearly, and the price of the inferior home-grown grain has fallen considerably. More or less concurrently with this greatly improved methods of milling have come into vogue, and the farmer, perhaps not unnaturally, associates the two facts, and all too frequently blames the miller for his reduced margin of profit. A little closer examination of this complicated problem shows that the tendency for the last thirty years or so has been for the yield per acre of grain to rise, and the quality, as estimated by the percentage of gluten present, to fall.[1]

Now in some way or other, precisely how we do not know, the capacity of wheat to yield a strong flour, or its "quality," is bound up in this mysterious mixture of proteids grouped together as gluten, so that if the blame must be apportioned, it rests on those who injudiciously selected wheats for cropping power in preference to quality. Meanwhile, such fine old varieties as Golden Drop, Red Lammas, and Nursery wheats are steadily being driven out of cultivation by varieties slightly superior in yield, but far poorer in quality.

The great importance of making the most of our home wheat-supply has been insisted on time after time by the National Association of British and Irish Millers, and one of the methods they have suggested is to raise improved strains of these good varieties, either by hybridising or by selection. Experiments along these lines have been carried out for the last three seasons by the Cambridge University Department of Agriculture. In the first place wheats known to yield a good quality grain have been crossed together with the object of finding more vigorous races among the progeny of the hybrids. Further, varieties selected from a collection of several hundreds for possessing such characters as a strong, resilient straw, a short period of maturation, and freedom from various diseases, have also been used as parent wheats.

So far it is early to predict any results of technical value, but a number of results of scientific interest have already been arrived at in connection with Mendel's laws of inheritance. The flowers of wheat being autogamous are specially advantageous for such work, as Spielman's careful researches on wheat-breeding, carried out without any previous knowledge of Mendel's work, have shown. Spielman has already recognised that lax ears, the lack of awns, velvety chaff, and red colour are dominant characters, while dense ears, the presence of awns, glabrous chaff and white colour are the corresponding recessive characters.

These results have already been amply confirmed.

Thus from crosses between beardless and bearded wheats the resulting hybrids have invariably shown the beardless character, while their progeny have consisted of beardless and bearded forms in the proportion of three to one. Similar results have been obtained on crossing lax and dense eared races, rough and smooth chaffed, and red and white, though in the last case it has so far been impossible, owing to bad ripening, to distinguish clearly enough between red and white chaff to establish their proportions.

At the same time it has been shown that the sharply keeled glumes found in *Triticum turgidum, e.g.* are dominant over the glumes with rounded bases occurring commonly in the varieties of *T. vulgare,* that the grey colour of glumes and paleæ is dominant over red and white, that broad leaves are dominant over narrow, and rough ones over smooth, that certain groups of bristles on the ridges of the stem which distinguish some varieties are dominant over the ridges without bristles, and that hollow stems are dominant over pithy stems. With regard to grain characters, the long and narrow type is dominant over the short and round, and the red over white. At the same time certain complications have been met with which will entail further investigation. Thus the rough-chaffed grey Rivet's wheat, when crossed with a smooth-chaffed white or red wheat, gives hybrids which vary considerably both in the roughness and colour of the chaff, some being almost glabrous and showing decidedly the red or white colour as well as the grey. The same impure dominance of the rough chaff and colour is found in the following generation. Where other rough-chaffed wheats have been made use of in the place of Rivet wheat though this character has been purely dominant.

Further, particularly among the progeny of the hybrids, there is a marked tendency for the various characters to become intensified. Medium lax, for instance, becomes very lax, the grey colour becomes almost black, and the red a deep brown. At the same time, unexpected forms appear in this generation showing characters unrepresented in either parent. The commonest of these, so far, has been a spelt-like wheat with peculiarly lax ears, thick glumes, and the typically closed spikelets of *T. spelta.* Many of these exceptional forms are sterile—probably owing to imperfectly developed pollen.

These botanical characteristics are, however, of little importance technically, the farmer and miller being concerned chiefly with the quality, yield, hardiness, time of ripening, susceptibility to disease, &c., characteristics, at present practically unexamined, which one might term "constitutional."

The quality of the grain can, to a certain extent, be judged by the hardness and translucency of its endosperm, the poor starchy grain being soft and opaque. Accepting this as a guide, then, good quality is a dominant character, at all events so far as an examination of the first generation of the hybrids goes. The late ripening habit is also dominant over the early ripening habit. As an example, *T. Polonicum,* ripening early in August when sown about the middle of March, was crossed with Rivet wheat ripening late in August when autumn sown. The hybrid grains were sown on March 15, and produced plants which ripened their grain about the middle of September—simultaneously with Rivet wheat sown on the same date.

Experiments on the susceptibility to disease are also being carried out. This point is being investigated both with rusts and mildew, the two serious wheat diseases, inasmuch as they are untreatable. For the purpose of the experiment, in 1901 Michigan Bronze and a wheat with the Michigan Bronze strain in it, viz. Red King, both liable to rust, were crossed with Rivet wheat, which is practically immune. Reciprocal crosses were made in each case. The following year the hybrids were the most badly rusted plants among the experimental plots, and there was nothing to choose between the plants with Rivet wheat as male or female. Incidentally, then, it might appear to anyone who accepted Eriksson's views that in the case of Rivet wheat ♀ × Red King or Michigan Bronze ♂, the so-called "mycoplasma" had reached the hybrid grain by way of

[1] The figures are set out in detail in Girard and Lindet's "Le Froment et sa Mouture," p. 101. (Paris, 1903.)

the generative nuclei. But is such an interpretation possible? I think not.

On harvesting the plants the grain was found to be badly shrivelled, the Michigan Bronze crosses only producing three grains, none of which germinated. From about three hundred grains of the Rivet and Red King crosses, two hundred and sixty plants were raised. The rust appeared on these as early as March 16, and by June 15 many plants were orange-coloured even on the highest leaves. On counting out the plot, 78 plants were found to be free from disease, 118 were slightly infected, and 64 were badly attacked. By June 29 the epidemic seemed to be at its height, and a second count showed that the number of disease-free plants was reduced to 64, while 195 were infected, for the most part badly.[1]

These figures seem to be too close an approximation to the Mendelian ratio of 1 : 3 to be a mere accident, especially when taken in conjunction with the results of the first generation. The susceptibility of wheat to the attacks of rust is therefore a definite Mendelian character.

If further researches should show that this capacity for resisting the attacks of disease-producing fungi is in reality a tangible characteristic, the plant-breeder, at all events, will have definite lines to go upon in attempting to solve one of our most important agricultural problems, namely, that of producing disease-resisting strains.

R. H. BIFFEN.

PROBABLE ERROR IN VITAL STATISTICS.

A PAPER on "The Degree of Accuracy of Statistical Data," by Mr. Carl C. Engberg, has been published by the University of Nebraska. "This paper," Mr. Engberg tells us, "is written as a protest against the unnecessary refinement of statistical computations as carried out by the biometricians of to-day." Mr. Engberg complains that the more "prominent biometricians" have worked with five or six figures when they might have worked with three or four with equally good results. He illustrates this by comparing Prof. Pearson's work on enteric fever, published in 1894, with a revision of it by himself using only three places of decimals. He considers that the one is as good as the other. He does not, however, apply the test for relative goodness of fit of observation to theory—*Phil. Mag.*, July, 1900—but discards it without examining the analysis by which it is reached, on the basis of a paradox that he has not been able to see through. He appears to dislike the test because if 16,000 observations are distributed in the same proportions in n groups as 1000 observations the former distribution shows a lower probability for the fit than the latter, if the same curve be used in both cases. This, however, must be right. 16,000 observations should give a result nearer a smooth curve than 1000. The percentage error has been discarded for years by trained biometricians; it was merely a temporary *modus vivendi*.

As to the use of a greater or less number of decimal places, to those who work with mechanical calculators the number is practically indifferent, and to trained computators even a 7 or 10 figure table of logarithms is hardly slower in use than a 4 or 5 figure table. But are the decimal places when reached worth having? Very often not, very often they are. Mr. Engberg seems quite incapable of distinguishing between the two classes of cases. The only means of testing is to consider the probable errors of the results. The theory of the probable errors of the constants of frequency curves was not given until 1898, and it was not possible to say in 1894 how many places of decimals were or were not necessary. Mr. Engberg appears to think that because vital statistics are tabled to one or even four year units, it is impossible to ascertain the values of constants to two or three decimal places of those units. He states, vaguely, that "the constants cannot be more accurate than the data upon which they are based." He might well have asked the American actuaries for their views on this point! Practical men do not work to 6 or 10 figures for the mere pleasure of it, and in the particular case cited by Mr. Engberg—"Makeham's c"—we have a constant which has often to be raised to the fiftieth power! Does Mr. Engberg believe that the mean age at death of a population of several millions, classified solely by year of age at death, cannot be found to less than the rough year which is the basis of the grouping?

Mr. Engberg says that his "paper has not been written in a fault-finding spirit by a detractor of the new science of biometry, but by a teacher of the science." It seems a pity that Mr. Engberg should not have studied either the history or literature of the science he is teaching, or, apparently, have received a training in mathematical statistics. In the former case he would have known that the method he suggests on p. 9 has been long in use (Yule, *Proceedings* of Royal Statistical Society, vol. lx., part iv., 1897), and the inner meaning of tables of powers for testing the *last* column of high moment tables would have been obvious to him. In the latter case he would have made a valid criticism of over-many decimal places by simply showing that they gave results beyond the probable error of the constant involved, or did not improve the goodness of fit as tested by a legitimate method. We are doubtful whether the growing practice of appointing teachers of biometry in the American universities without preliminary training is really helping the science forward. It leads, it is true, to a multitude of biometric papers, but very few of these are of permanent scientific value.

[1] One plant overlooked.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—On Thursday, November 19, an election took place of great importance in relation to the advancement of the study of mental science in Oxford—that of Dr. W. MacDougall to the readership in psychology founded some years ago by Mr. Wilde. The first reader was Mr. Stout, the well-known editor of *Mind*, who last summer resigned the Oxford appointment for a professorship at St. Andrews. His successor will no doubt follow in Mr. Stout's footsteps, but those who appreciate the value of the experimental method in psychology confidently anticipate that opportunity will now be given for this study in Oxford. Dr. MacDougall has himself approached the subject from the experimental side, and is the author of very important researches on the physiology of the nervous system, among which those relating to the theory of colour vision may be taken as examples. As a member of the Cambridge Anthropological Expedition to Torres Straits and Borneo, he conducted experimental researches on the mental processes of savages, which afford substantial evidence of his power as an investigator. When to this it is added that he is no less a master of the older methods than of the new, and is regarded as a man of power alike by physiologists and by philosophers, the university may well be congratulated on so valuable an accession to its intellectual forces. Against any regret that may be felt that the new reader is not an Oxford man, the fact may be set off that one of the most successful and influential of American experimental psychologists—Prof. Titchener—received his training in both sides of the subject at Oxford.

CAMBRIDGE.—Dr. Hobson, F.R.S., has been appointed the first Stokes lecturer, and Dr. Baker, F.R.S., the first Cayley lecturer, in mathematics.

An Isaac Newton Studentship of 200*l.* a year for three years, for research in astronomy and astronomical physics, will be vacant in the Lent term, 1904. Candidates must be bachelors of arts under twenty-five years of age. Applications are to be sent to the Vice-Chancellor by January 26.

The degree of D.Litt. is to be conferred *honoris causa* on Prof. Théophile Homolle, member of the Institute of France, director of the French School of Athens.

Prof. Woodhead, Mr. J. E. Purvis, Dr. Tatham, Dr. Lane Notter, and Dr. R. D. Sweeting have been appointed examiners in State medicine for the diploma in public health.

The scheme for the establishment of a geographical school and the institution of a special examination in geography and a diploma in geography will be submitted to Senate for adoption on December 5.